REFLECTIONS

ON THE

ANATOMY AND PHYSIOLOGY

OF

SOME PARTS OF THE EYE.

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MOBILE:
PRINTED AT THE DAILY REGISTER OFFICE.
1871.

ANATOMICAL AND PHYSIOLOGICAL REFLECTIONS

ON SOME PARTS OF THE EYE.

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It is now nearly a quarter of a century since I published, in the American Journal of the Medical Science, certain anatomical and physiological reflections on some important parts of the human eye; and I design, upon the present occasion, to reproduce for your consideration these investigations in a more particular and, I think, attractive form.

Especially do I do this because I recognize the fact that the opinions I then expressed, are beginning to receive the sanction of the profession in Europe as well as in this country.

The recent progress of the medical science has of late years been so rapid that it may be now said to occupy a position incomparably superior to that enjoyed by most of the other professions. The reciprocal bearing of its various branches, one with another, which is now being daily exhibited, imposes the belief that it must shortly attain the character of a completed and well established science.

While this perfected condition of the medical profession will hereafter presuppose an accurate knowledge of its various departments, it can never, however, deter the investigator from prosecuting his researches in any determinate direction, if he fails not to forget the mutual relations which his results should ultimately present with the connecting sciences. This, indeed, is the goal that we should endeavor to attain, and that must be regarded as the criterion of all future inquiries.

While among the litigated points of anatomy and physiology, there are many questions rendered particularly intricate from the numerous bearings which they present, there are others which require but the scrutiny of an anatomical eye to lead us almost naturally to the physiological inductions which appear to follow as the sequel This is, perhaps, the nature of the examination into which we are about to enter.

While studying absorption, and believing, from the concurrent

testimony of several physiologists and the plausibility of their researches, that the venous system plays a prominent part in the discharge of this important function, the eye presented itself to me as said to be an organ totally deprived of lymphatics, which consequently seemed to be an argument verifying the assertion. The question arose, whether the eye possessed any peculiar vascular arrangement which distinguished it in this respect from any other organ, as it was deprived of lymphatics for the accomplishment of absorption. A careful anatomical examination was instituted, by which I purposed to determine the relations which exist between the constituent parts of that organ, and their peculiarities of structure.

In undertaking this subject, and making reference to those works which were inservient to my purpose, I found that I had engaged in a vast field already explored by those whose names are destined long to reign with oracular authority over anatomical questions. Indeed, the names of *Sœmmerring*, *Zinn*, *Arnold*, and others, appeared to preclude the possibility of my determining anything positive with regard to this problem. But as from every subject truth may be said to radiate like the beams of light in various directions, the hope has been encouraged that it is given to every one to view it in some one of those numerous phases, which may possibly have escaped the scrutiny of the imposing authorities, whose names have been mentioned above.

Proceeding then, without further preliminaries, to the disscussion of a subject no less intricate than interesting, we will, for the facilities of description and the more orderly exposition of the facts which support our views, comprise what we have to say under two sections: examining under the first head such parts of the eye, the complexity of whose structures fails not to attract our serious attention; and under the second, making such physiological inferences from the structure of these respective membranes, as may elucidate the functions they discharge in so delicate an organ as the eye.

As our remarks will, therefore, particularly bear upon the function of absorption, and the nutritive acts as they transpire in the eye, attention will be almost solely directed to the *choroid coat* and its appendages, the *iris* and *ciliary processes*, while the hyaloid membrane and body will also engage our time, so far as they may be connected with the vascular arrangement of the organ.

After my first examination of an eye, prior to my attention being especially engrossed by this subject, I found that my impressions concerning the choroid coat were by far the most striking. I was no less impressed with that peculiar deposite [than which there is nothing more singular in the whole economy] investing the entire membrane, than that there should be so large a reticulum of blood vessels in so small a space. Indeed, the vascularity of this coat is

such that the learned Professor Cruveilheir justly remarks that the words *choroid* and *vascular* are synonymous, and it may not be irrelevant, perhaps, to allude to the etymology which sanctions such an opinion.

The term *chorion*, applied to one of the membranes enveloping the fœtus is the Greek word *Χοριον*, which is derived from *Χώρος*—domicilium—a house being indeed an abode for the fœtus, a protective envelope of indispensable necessity to its nutritive acts.

But this membrane being formed of a network of vessels, its extreme vascularity became the characteristic feature which served to discriminate it from every other membrane in the body.

When, indeed, Hyrophilus described the choroid coat its vascularity likened it at once to the chorion, and though we will not at present anticipate the parallel which we are about to establish between these two membranes, let me only state that the word is compounded of *Χόριον*—chorion, and *Εἶδος*—resemblance.

Of the general direction and relation of this vascular layer it is needless to speak, as this would be but reproducing what every elementary work on anatomy contains, but of its anterior termination and structure, concerning which there is such diversity of opinion, we will furnish some account.

Since the days of the celebrated injector, Ruysch, the choroid has been regarded as composed of three distinct layers, which are readily exhibited when recourse is had to the proper modes of preparation. The outer layer which is manifest to the unassisted eye, is formed by a multitude of blood vessels, held together by cellular or filamentous tissue (these cells are pressed together, colorless, having short branches which penetrate a striated tissue partially nucleated), and when examined with the lens present a tortuous dissection, running into centres, from whence radiate a number of convoluted capillaries. From the multiplied centres, the rendezvous of these arborescent ramifications, the vessels (which are altogether composed of veins,) have been called venæ-vorticosæ, and contrast very strikingly with those of the layer beneath, which is made beautifully conspicuous when both are injected.

The lamina immediately beneath is arterial, its vessels coursing lengthways towards the anterior part of the eye. This is the layer which was first so beautifully injected by Ruysch, and has ever since borne his name, tunica Ruyschiana. This part when well injected gives to the choroid coat the appearance of a sheet of gold. Very excellent representations of this are given in Zinn (J. G. Zinn, Descriptio Anatomica, Oculi Humani, Tab. 4, Fig. 1st, 2d,) and Soemmerring, (Soemmerring Oculi Humani, Explicatio, Tabulo Quinto, Figura Septima). The elastic membrane of the choroid is there almost transparent, perfectly hyaline; it may be termed a structureless membrane, studded here and there by nuclei, which give it a beau-

tiful appearance. This delicate membrane lines the inner side of the tunica Ruyschiana.

The next lamina which forms the inner part of the coat in contact with the retina, is not readily exhibited in the human eye, though in the sheep it is always easily demonstrated. This is the membrana pigmenti. After maceration a separation of this portion is most easily effected by commencing at the *tapetum lucidum*, where the layer possesses the greatest thickness; conveyed beneath the microscope, it presents the beautiful appearance of a hexagonal tessellated pavement, each hexagon being a cell in which the granules of pigment are secreted, that portion of its extent forming the tapetum being void of pigment globules, though the cells exist.

Now, after the cursory view of the several constituent parts of the choroid, let us examine the mode of their termination at the anterior part of the eye. Indeed, this is the question which it behooves us to examine, and its careful consideration will form the principal object of the present remarks. The generally received opinion is that there is a mutual reception of the ciliary processes, iris and ciliary ligament, and in such a manner, we are told, as to allow of a ready separation of the iris from the rest of the choroid, upon a knowledge of which assertion rests the operation for artificial pupil. But the exact mode of termination of these several structures, nay, even their exact nature, is by no means settled.

A signal illustration of the diversity of opinions on this subject, may be found by perusing a work published by a distinguished physiologist of Germany, Rudolph Wagner, who, in speaking of the ciliary processes, calls them *muscular*, an opinion now professed by few, and which is certainly in formal contradiction with the result of my observations, as far as they have extended among several classes of animals, the sheep, ox, dog, and cat, and in the human species.

Home and Wallace (from their observations on the inferior animals,) believe the ciliary processes to be muscular, and to aid in adjusting the focal distance of the lens, to the capsule of which they are indirectly connected. (Structure of the Eye, by W. C. Wallace.) Casper Wistar says: "The intimate structure and function of the ciliary processes *are unknown*," and also remarks, "that many think them *erectile*, altering the position of the lens by their expansion or contraction." He says in another place, "their outer extremities seem to adhere anteriorly to the iris, and posteriorly to the retina, and to the capsule of the vitreous humor." Dr. Irwin (referred to in John and Charles Bell's Anatomy and Physiology, p. 226, vol. 2.) says *they are muscular*, and goes to work to demonstrate how they move the lens. Leidy describes the ciliary processes as composed of "all the elements of the choroid coat;" he describes the artery in them as convoluted, (this I think must have been done by a forced injection,) while Rosow, quoted as authority on this subject by Stell-

wag, says: "The structure of the ciliary processes is very analogous to that of the choroid. It may be divided into the same layers, with the exception of the chorio-capillaries (membrana Ruyschiana, the arterial coat of the choroid,) which ends at the ora serrata." Again, Claude Bernard and Charles Huette, when describing the anatomy of the choroid coat, on page 142, says: "Les procès ciliaires, plis constitués par le feuillet interne de la choroide, flattent derrière l'iris et entoment la circonférence du cristallin avec lequel ils n'ont aucune adhérence intime." Here we are told distinctly that the ciliary processes are made up entirely of the inner layer of the choroid (the membrana pigmenti,) that they have no vessels in them, for on page 141 the choroid coat is thus described: "La choroide tapisse la face interne de la sclérotique à laquelle elle adhère faiblement. Cette membrane est composée de deux feuillets distincts, l'une interne, entièrement constitue par du pigment, l'autre externe et essentiellement vasculeux." Handy, in his Anatomy, page 336, says the function of the ciliary process "*is to secrete or furnish the black pigment.*" Whatever be the mode of union of the *iris* and *choroid*, one fact may be easily established, which is, that the adhesions between the two are far more intimate than is generally believed.

To convince ones self of this fact, we need but observe in dissecting an eye that the *choroid* and *iris* continue still to protect the humors after the removal of the sclerotica and cornea. There is only a slight adhesion of the iris and choroid with the sclerotica. This connection appears to me to be of a muscular character, particularly in the eye of the bird, and in the sheep, where the anterior layer of the iris, which is clearly muscular, seems to give off a multitude of tendinous slips attached directly to the choroid under the form of a circular white line, improperly callled "*annulus gangliformis, seu ganglion annulare,*" by Soemmerring *(Soemerring, Icones Oculi Humani, Explicatio Tabulae Quintæ, Figura Septima.)* This is no ganglion, but muscular tissue, not deserving the appellation which it often bears of ciliary ligament; it unites the muscular or anterior layer of the iris with the choroid, just as the posterior layer, which I consider as altogether vascular, is directly continuous with that tunic. The pulpy appearance, which the ciliary ligament may sometimes assume, is apparently due to the rupture of its slight attachment to the sclerotica, for this circumstance leaves a somewhat similar appearance upon the corresponding part of the sclerotica.

Such, then, is the nature of the so-called ciliary ligament, a bond of union between the muscular or anterior layer of the iris and the choroid, adhering *slightly* to the sclerotica, but *firmly* to the choroid, from which it is torn, but does not naturally separate, in operating for artificial pupil. But the posterior layer of the iris is a direct continuation of the choroid, and therefore essentially vascular, the blood vessels of the latter running forward and downward, passing

over and concealing the interior surface of the ciliary muscle, for which reason this structure is much less visible on the inner than outer surface. This direct continuity of the frame-work of the iris with the choroid, explains the constant integrity of the membranes after removal of the sclerotica, as they literally are one and the same. This direct continuation of the blood-vessels into the iris is particularly visible in injecting the eye of a fœtus, whose pupillary membrane still exists, as may be seen in the plates accompanying Jules Cloquet's Monograph on this subject. (Memoire sur la membrane pupillaire, et sur la formation du petit circle artériel de l'iris, par Jules Cloquet.) However, I may here observe, and would wish particular attention to the remark, that all the blood vessels do not pass into the iris. Of this I have had repeated opportunity of satisfying myself by injecting the arteries of the choroid tunic.

The ciliary processes, the nature of whose structure has been so variously interpreted, are positively vascular, and present so singular an arrangement of its vessels, that my surprise is great in observing the uncertainty of most authors on this subject. It is true that their nature and the office they probably fulfil were anticipated by ancient writers, but of this we have nothing but the most hypothetical accounts.

The first experiments which were performed on this subject, were by Ribes. (Memoires de la Societe Médicale d'Emulation, vol. 8,) in a series of essays, published in 1814 and 1816; and here I must acknowledge great assistance from the writings of this accurate and laborious investigator, many of whose researches I am proud to have been able to verify, as I am now more than ever convinced they carry with them the stamp of truth.

Some of the many views entertained with reference to the function of the ciliary processes were, first, that they were destined to move the iris, or to fix the crystalline lens, over which they exerted that influence, which allowed the eye to adapt itself to various distances. It was believed again that they secreted the black pigment which invests the chloroid and posterior face of the iris.

It is needless to confute these assertions, as the muscularity of the iris, the membrana pigmenti, and the separation of the ciliary processes from the crystalline lens, are overwhelming arguments to the contrary. Moreover, as observed above, these remarkable structures are altogether vascular, the blood vessels of the choroid coat extending directly into them in the most visible manner, and presenting one of the most beautiful appearances that can be exhibited from injections of any part of the body.

When, indeed, a ciliary process has been divested of that inspissated pigment in which it is disguised, and placed on a lamina of glass, is conveyed beneath the field of the microscope, we may distinctly discover the presence of a hollow canal which, when it reaches the free extremity of the ciliary processes, affects a recur-

rent direction, coursing backwards parallel to the first, so as to form a perfect loop. Eccentric to this loop there is a fringed arrangement of cellular tissue which, indeed, may be distinctly seen with the naked eye.

Now, after a successful injection of colored ichthyocolla through the common or internal carotid, it will be found that the canal in the ciliary process is an artery derived from the arterial layer of the choroid coat. Again, if we inject by the jugular vein (which is much less apt to succeed owing to the fragility of the veins in the choroid), the injection passes into the fringes of the ciliary processes. The vascularity of these appendages to the choroid then is evident.

Before we proceed to the inferences deduced from this fact, let me further remark, that on no occasion have I found that the substances used in the injections passed into the hyaloid membrane of the vitreous body. I have never, consequently, seen the hyaloid artery described by Cloquet and others as passing through this humor to the posterior part of the lens, though the arteria centralis retinæ has been easily and fully injected. In these respects do I fully concur with Ribes, who was no more successful in injecting the hyaloid membrane.

Besides these ciliary processes described as dependencies of the choroid coat, there are a distinct series of similar structures connected, as I believe them to be, with the retina. Though their presence has been denied by many authors, they are described by others under the name of *ciliary processes of the vitreous body.* They are by no means the depresions of the *zonula zinni* which give that fluted appearance to the canal of Petit, which has led anatomists to term this part of the eye the *canal godronné.* With a good lens in a favorable light the fringes of these ciliary processes may be distinctly seen, and they are also susceptible of being injected, though I am not prepared to determine whether the injection passes into them through the central artery of the retina, or from any immediate connection which may exist between them and the ciliary processes of the choroid coat. Indeed, there is a mutual reception between the processes of the choroid coat and those of the vitreous body. This is now a well known fact; even Horner, in his second volume, page 415, says: "The ciliary processes impress the neighboring portion of the tunica hyaloidea with their shape, and leave upon it the black pigment with which they themselves are covered." It is evidently from this juxtaposition that the latter becomes also invested with the pigment, and a communication between these two sets of processes seems very probable.

If I have supposed the processes of the vitreous body to be connected with the retina, it is from their attachment to the zonula zinni, which I regard as a continuation of the arterial or internal layer of the retina. Many of my dissections justify this belief, and

some microscopists have followed the nervous, pulpy filaments of the retina along this part to the peripheral portion of the crystalline lens, notwithstanding what Stellwag says on page 128: "The retina is bounded posteriorly by the optic nerve entrance, anteriorly by the ora serrata, where it becomes adherent to the retina." I am inclined to suppose that it is through the zonula zinni that the capsule of the crystalline lens receives blood vessels, and that these are derived from the retina, as there has often been an appearance of vascularity about the lens without any traces of it in the vitreous body. Stellwag says, on page 109, line ninth: "Nutrition is carried on through vessels of the retina, uvea." and

I am sorry that, while in accordance with Ribes as regards the non-vascularity of the hyaloid membrane and vitreous body, I find that my observations must be placed in opposition to those of Cloquet and Muller. The latter particularly describes the hyaloid artery as passing through the vitreous body, furnishing its membrane, reaching the posterior capsule of the lens, upon which it is spent. He further mentions a fœtal structure, discovered by himself, under the name of *capsulo-pupillary* membrane which also receives its blood-vessels from this artery. It may be that this central artery of the vitreous body exists in the fœtus. Stellwag believes it cannot be found after fœtal life. H. Muller says that "In the calf and horse its string-like tendinous remains are observed after fœtal life." Meissner has noticed the remains of this structure in the human subject with the opthalmoscope. Toussaint, Liebreich, and Sämisch have observed its remains as a tendinous band stretching from the papilla to the posterior wall of the crystalline lens, and then expanding to a flat opacity. Zehender says that he has observed this vessel filled with blood. Henle believes all of these vessels are remains of fœtal life.

Notwithstanding these authorities, I must continue even now, as I did formerly, in my belief, that the humors of the eye are altogether transparent, being deprived of blood-vessels which otherwise would intercept the rays of light, or at least materially interfere with vision, especially as I am countenanced in that opinion by so high an authority as Carl Stellwag, who says, when speaking of this humor (corpus vitreum), "*It is perfectly structureless, without vessels or nerves.*"

Regarding, then, the humors of the eye as completely isolated from the rest of that organ, being enveloped by their proper membranes, which preserving the character of true serous membranes are remarkable for their extreme tenuity and non-vascularity, the question arises, *in what manner is secretion, nutrition and absorption effected?*

Before replying to this question, let me observe that it is not very long ago since the function of absorption, supposed to be the sole prerogative of the lymphatic system, was disputed for by another

order of vessels, whose important office was made known to us by the valued experiments of Magendie. This distinguished physiologist proved, by a series of experiments which we cannot here detail, that the veins positively absorb. Again, he was conclusive in the further result, that during this process the veins manifested a peculiar predilection for liquids, which were taken up with the greatest rapidity.

Now, taking the anatomical condition of the eye as the basis of a reply to the above question, and pointing out its alliance to the physiological fact just mentioned, we will at once discover a singular parallel between the office of the choroid coat and that of the chorion enveloping the fœtus. Indeed, like this latter, the choroid is alone inservient to all the nutritive and secretory processes transpiring in the parts which it envelops, and this might almost be inferred from its extreme vascularity and the peculiar distribution of its vessels in those several appendages termed ciliary processes. These remarkable structures are organs of secretion. This will be readily understood from what has been said of the central arterial loop, and the venous fringes, which together form a ciliary process; for what would be the object of this extraordinary arrangement were it not to realize some such important office in the vital operations of this perfect organ.

We can certainly imagine that the blood passing through these processes is subjected to an operation allowing the secretion of that aqueous fluid, which by penetrating into the cells of the hyaloid membrane will constitute the vitreous humor. Moreover, from the evident connection of the processes of the vitreous body with, and their penetration into, the capsule of the lens (a fact verified by Ribes) we may readily admit a similar operation as going on in this place, which would explain the possibility of capsular cataract, while the lens itself is perfectly transparent. Stellwag says on page 495, line 24th, "The ciliary processes *seem* to have a great deal to do with the nutrition of the lens."

Now, after the secretion of these humors (perhaps even the aqueous also) the fringed extremities of the processes, being venous, will carry on absorption of the stagnant or vitiated products as follows: The cellulo-vascular fringes of the processes of the vitreous body will pump up the vitreous humor, while from the connection of these processes with those of the choroid, the former will receive in their turn the nutritive elements for the restorative process of secretion. The processes of the choroid, from their pendent condition in the posterior chamber, are admirably adapted for the absorption of the aqueous humor also.

If, after these anatomical details, our conclusions do not appear to be fully justified, there appears to be some pathological facts which will lend us further support in the confirmation of our belief.

As Ribes observes in the excellent memoir alluded to, Scarpa was

in the habit of operating on cataractous eyes, by passing the lens into the anterior chamber, believing that it would be there more easily absorbed; but it will be seen that this opinion, which was the result of a preconceived notion, was very soon abandoned. Heister, in his Institutions de Chirurgie, particularly refers to the necessity of securing the lens in the posterior chamber, as it will there be more readily absorbed, and we know at present that the appearance of the lens in the anterior chamber is always an embarrassing condition, as it requires a length of time for its disappearance. The serious inconvenience which ensues, is perhaps, owing to the fact that the aqueous humor must first wash away the lens by degrees, and then pass into the posterior chamber to be absorbed. Such, indeed, was the conviction that absorption was more readily induced in the posterior chamber, that Heister and others were in the habit of placing the patient on the border of a bed with his head so depressed, as by frictions over the eye and blows on the back of the head, the lens might be made to pass back again into posterior chamber. In cases of hypopion the same method was made use of, and we would finally remark that the mass of black pigment which invests the eye is thickest precisely in that spot where these wonderfully constructed processes exist.

Stellwag, on page 553, line third, says: "It is not advisable to push the fragments of cataract into the anterior chamber, as they collect at the bottom of the chamber and irritate the iris. Their sinking in the vitreous is not attended with peculiar danger, as they are *then readily absorbed*, and only a small portion of them reach there, for, on account of their softness, they are usually stripped off and remain in the posterior chamber." In another place he says: "Leave nothing in the anterior chamber, not even a flocculi" after the operation for extraction of cataract. This, to my mind, establishes the fact that so high an authority as Stellwag believes absorption takes place better and more readily in the posterior than the anterior chamber. Again: when these views were first made known to the medical public, Dr. Addinell Hewson (one of the surgeons at that time of Wills' hospital and lecturer on surgery in the Philadelphia association for medical instruction, as well as editor of Wm. Mackenzie's valuable work on diseases of the eye) thus speaks of my researches, page 772, line 40: "Dr. R. Fraser Michel, of Charleston, South Carolina, has reasoned in a very ingenious way on the influence probably exerted by the ciliary processes in effecting the rapid absorption which we see taking place in the chamber of the aqueous humor. From contemplating the great vascularity, both arterial and venous, of this structure, and its total want of lymphatics, he has inferred that the function of this body is both to secrete the humor of the aqueous chamber, and to carry on the absorption of all that is removed therefrom by such means."

"The opinion that the aqueous humor is derived from such a

source, derives at least some support from the rapidity with which it is renewed after evacuation from the anterior chamber. The length of time required for its reäccumulation, under such circumstances, must indeed be very short to enable M. Desmarres to say, in speaking of the accident of prolapsus of the iris in making the section of the cornea for extraction: 'Toutefois, on aurait lieu d'esperer, en attendant quelques minutes et en recommandant au malade de tenir les yeux fermés, de pouvoir reprendre l'operation inachevée. L'iris, en effet, ne tarde pas, par suite de la rapide reproduction de l'humeur aqueuse, à l'éloignes de la cornée.' And then the membrane of aqueous humor, lining the anterior chamber, is so thin, delicate and devoid of vascularity, as to lead us to seek for some other source from which so rapid a product can be derived. The part must be, indeed, highly vitalized, which can so rapidly perform such a function of secretion, and the degree of vitality, in a secreting organ at least, is, by a law of physiology, in direct ratio with its vascularity. Hence, Dr. R. F. Michel, and those who advocate with him such a source for the aqueous humor as that of the ciliary processes, have, we think, a very fair amount of reason in support of their doctrine. The experiments of Magendie, and others, on the facility with which fluids are taken up by venous radicles, might also justify the belief in the absorption of substances, such as fragments of broken-up lens, being accomplished by the same structures here, seeing that this part of the eye at least is almost, if not totally, devoid of the other source of absorption. But pathologists are as yet divided in opinion as to the manner in which the removal of a broken-up lens is accomplished, whether by direct absorption or solution. Be this as it may, and even admitting that the removal of a broken-up lens is more rapidly effected in the anterior than in the posterior chamber (*a fact which we do not think has yet been conclusively established*) we cannot admit that the advantages thus to be derived from throwing the fragments into the anterior chamber are at all commensurate with the evil consequences of such a proceedure."

In conclusion, permit me to acknowledge my indebtedness to my brother and preceptor, Dr. Middleton Michel, professor of physiology in the medical college of the state of South Carolina, for his valuable aid and counsel in the former preparation of this paper for the medical press, and for his important assistance as an injector and microscopist.

Such then is the nature of the facts, which, though they might be dwelt upon more discursively, are sufficient, we deem, to prove that structures so vascular as the choroid and ciliary processes were unquestionably destined to fulfil the high office which (twenty-five years ago) we assigned them.